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EFFECT OF CLIMATE ON STANDARD AIRPLANE-WING COVERINGS

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EFFECT OF CLIMATE ON STANDARD AIRPLANE-WING COVERINGS.

PURPOSE.

The purpose of this series of experiments is to determine the relative suitability of various doping schemes, using standard doping materials, in the different climates represented by the locations of the following stations:

McCook Field, Dayton, Ohio.
France Field, Panama.
March Field, Calif.
Fort St. Michael, Alaska.
Fort Gibbon, Alaska.
Naval Air Station, Hampton Roads, Va.

The original selection of stations also included Texas and the Philippines, but through some difficulty at these points the exposure panels were not returned for test.

CONCLUSIONS.

Any pigmented protective covering is better than a clear dope or clear dope and varnish.

Pigmented dopes are superior to enamels with special reference to aging and weathering properties.

Coatings of clear dope, with or without a finishing coat of clear varnish, are the least satisfactory of all covering schemes tried.

Clear nitrate or clear acetate dopes give equally satisfactory results when used in conjunction with a pigmented protective coating.

The most severe climates of any included in the above list of stations are Panama; Dayton, Ohio; and Norfolk, Va.

MATERIAL.

The material used for covering was standard grade "A" cotton fabric having the following physical properties:

Threads per inch.		Tensile strength.		Weight per square yard (ounces).	Thread size.	
Warp.	Filling.	Warp.	Filling.		Warp.	Filling.
80	80	80	80	4.2	60/2	60/2

No linen fabric was used for the reason that former experiments indicated the superiority of cotton fabrics, especially over a period of exposure to the weather.

There were 12 doping schemes used and 4 panels of each scheme to permit of samples being submitted after continuous exposures of one month, three months, four months, and six months. Each station received one complete set of 48 panels, and the proper panels were forwarded to Dayton at the end of each exposure period. All tests were made in the laboratory of the Engineering Division, Dayton, Ohio.

Below are given formulas, trade names, and manufacturers' names of the various dopes, enamels, and pigmented dope used in this test:

CLEAR CELLULOSE ACETATE DOPE.

The clear cellulose acetate dope, four coats of which were applied in series A, C, D, G, H, I, J, K, and the third, fourth, and fifth coats of series L was United States standard No. 5 dope, code No. 32, manufactured by the Standard Varnish Co., of Staten Island, N. Y., and of the following formula:

Methyl acetate........................per cent..	60
Methyl ethyl ketone........................do....	10
Benzol........................do....	15
Acetone........................do....	9
Diacetone alcohol........................do....	6
Cellulose acetate..............ounces per gallon..	9
Triphenylphosphate........................do....	1.15
Benzyl acetate........................do....	.4
Benzyl benzoate........................do....	.8
Urea........................do....	.25

CLEAR CELLULOSE NITRATE DOPE.

The clear cellulose nitrate dope, four coats of which were applied in series B, E, F, and the first and second coats of series L, was du Pont No. 40, code No. 23, manufactured by the E. I. du Pont de Nemours & Co., 120 Broadway, New York City.

LIGHT ENAMEL.

The light enamel used for a finishing coat in series C, E, and L was gray wing enamel, manufactured by the John Lucas Co. (Inc.), Philadelphia, Pa. This was submitted through the Navy Department as the standard wing enamel used by them.

DARK ENAMEL.

The dark enamel used for a finishing coat in series D and F was olive-brown wing enamel "B," manufactured by the Glidden Co., Cleveland, Ohio.

KHAKI PIGMENTED NITRATE DOPE.

The khaki pigmented nitrate dope, two coats of which were used as finishing coats in series G, was Air Service pigmented covering No. 106, code No. 7, developed and manufactured by the Air Service, and of the following formula:

	Pounds.
Venetian red........................	1.20
Ultramarine blue........................	9.35
Yellow ochre........................	55.50
Castor oil........................	33.95
Paste to each 10 pounds clear du Pont No. 40 nitrate dope........................	1.9

RED PIGMENTED NITRATE DOPE.

The red pigmented nitrate dope, two coats of which were used as finishing coats in series F, was known as Air Service insignia, red, code No. 9, developed and manufactured by the Air Service, and of the following formula:

	Pounds.
Vermilion deep	83.3
Castor oil	16.7
Paste to each 10 pounds clear dope	1.5

WHITE PIGMENTED NITRATE DOPE.

The white pigmented nitrate dope, two coats of which were used as finishing coats in series I, was known as Air Service insignia, white, code No. 8, developed and manufactured by the Air Service, and of the following formula:

	Pounds.
Zinc oxide	77.8
Castor oil	22.2
Paste to each 10 pounds clear dope	1.0

BLUE PIGMENTED NITRATE DOPE.

The blue pigmented nitrate dope, two coats of which were used as finishing coats in series J, was code No. 2, identification color "blue," manufactured by the Titanine (Inc.) Union, N. J.

ALUMINIZED NITRATE DOPE.

The aluminated nitrate dope, two coats of which were used as finishing coats in series K, was used in formula of 1 pound powdered aluminum and 7 pounds du Pont 40 nitrate dope.

NAVY DOPING SCHEME.

The panels in series L were doped in accordance with the Navy doping scheme, which consisted of two coats of nitrate dope, du Pont No. 40, three coats of clear acetate, and two coats of gray enamel. The general idea of this scheme was to obtain the necessary tautness by the use of the nitrate dope and to get some slight degree of fireproofing by the use of the acetate dope.

PROCEDURE OF TESTS.

Exposure panels, 12 by 12 inches inside dimensions, were covered on the face and back with cotton fabric. The doping schemes used were as follows:

A. Clear acetate.
B. Clear nitrate.
C. Clear acetate with light enamel.
D. Clear acetate with dark enamel.
E. Clear nitrate with light enamel.
F. Clear nitrate with dark enamel.
G. Clear acetate with pigmented nitrate, khaki.
H. Clear acetate with pigmented nitrate, red.
I. Clear acetate with pigmented nitrate, white.
J. Clear acetate with pigmented nitrate, blue.
K. Clear acetate with aluminized nitrate.
L. Clear nitrate, clear acetate with light gray enamel (Navy scheme).

Four panels for each series were made for the purpose mentioned above. After the samples were completed and had dried for twenty-four hours, tautness measurements were made on each panel for use as a reference in measuring the tautness life of each covering.

The directions for exposing these panels were as follows: "A rack or frame should be built to permit the panels to face the south, and they should be at an angle of 45° from the horizontal. The side of the panel on which the metal tag is attached should be up at all times."

As each series was completed, each panel was tested, face and back, to determine (*a*) the tautness of the covering, (*b*) the tensile strength, (*c*) the tearing resistance, and (*d*) a visual and manual inspection of the condition of the covering.

APPARATUS.

Tautness measurements were made by the use of a McGowan tautness meter, which consists of a span the width of the rib spacing. This span has an Ames dial gauge fastened at the center. Known weights can be placed upon the gauge plunger and the deflection due to these weights is indicated on the gauge face. The three arbitrary weights are:

1. The plunger alone.
2. The plunger plus 3 ounces.
3. The plunger plus 24 ounces.

In making tautness determinations, using these weights a hysteresis diagram is developed which indicates the degree of tautness and the amount of "set" in the covering material. Visual and manual inspections were made by the operator.

SCOTT TEXTILE TESTING MACHINE.

All tensile strength and tearing resistance determinations were made, using an H. L. Scott vertical textile testing machine.

TORSION BALANCE.

All weight determinations were made, using a standard torsion balance.

RESULTS OF TESTS.

TENSILE STRENGTH.

Tensile strength determinations on samples which were exposed at the several fields are included in Table 1. The decrease in strength is noted for each sample over the entire exposure period for each station. A study of this strength loss will give a fair idea of the comparative severity of the climate at each station.

TAUTNESS DETERMINATIONS.

All tautness determinations were made, using a McGowan tautness meter, which is described above. In principle, this apparatus is correct, but when using wooden frames which have been exposed over the entire exposure period, the tautness determinations obtained are doubtful owing to the warping of the wood in the panels. Table 2 is offered, however, to show the general tendencies of the various coatings as indicated when using the above meter.

UNIT WEIGHTS OF WING COVERINGS.

The question of unit weight of wing coverings is of some importance to the designer and the manufacturer. Table

3 shows the original weights of the coverings before exposure and the weights of the same coverings after a continuous exposure of six months.

The clear nitrate dope was completely washed off as a result of six months' exposure, and the weight of the coating after exposure, as noted above, is the weight per square yard of the fabric alone. The weight of both panels, using light enamel as a finishing coat, was reduced mainly due to the fact of the enamel flaking off the doped surface, and the final weight as reported above is approximately the weight of the fabric plus the clear dope. The panel having a finishing coat of aluminized nitrate apparently increased in weight. This is believed to be due to the accumulation of dust and dirt, rather than to any properties of this coating.

TEAR RESISTANCE.

A typical group of results showing the effect of the several doping schemes on the tear resistance of standard airplane cotton and the effect of weathering on the tearing resistance of each doping scheme, is shown in Table 4. This table shows only the effect on the tearing strength of the filling for convenience, as the effect on the warp is of essentially the same magnitude and shows the same tendencies.

The tearing tests were made in accordance with the "strip-tear" method, which is as follows: A sample 6 inches long and 2 inches wide was cut down the center for a distance of 2 inches. One strip was placed in the top jaw and the other strip was placed in the lower or pulling jaw of the testing machine. The magnitude of the force necessary to tear this specimen along the direction of the cut was registered on the dial of the machine. The results of these tests are shown in Table 4.

LIFE OF CLEAR DOPE AND SPAR VARNISH COVERINGS.

In order to compare the life and performance of the older type doping scheme—that is, clear acetate dope with a finishing coat of high-grade spar varnish—data were obtained from the files of the Material Section of the Engineering Division regarding the performance of clear dope and clear varnish when exposed to the weather. An approximation of the average service life of these coatings is as follows:

Doping scheme.	Approximate service life.
Raftite and clear spar varnish [1]	1 to 2 months.
United States standard No. 5 and clear spar varnish	2 months.

[1] Raftite is a clear acetate dope developed by the R. A. F. and is the standard British clear acetate dope.

EFFECT OF SUNLIGHT, RAIN, ETC.

In obtaining the effect of sunlight, rain, etc., usually described as weathering, the panels were covered and doped on the face and back in the same manner. These panels were exposed by mounting on a skeleton rack, facing south, the panels raised at an angle of 45°. This condition of exposure was standard for all stations. The face, consequently, was exposed to the effects of sunlight, rain, temperature, and humidity changes, while the back or under side was exposed only to changes of temperature and humidity. In Table 5, the effect of sunlight, etc., on the face is shown over the entire exposure period by the tensile strength results, and the tensile strength of the back or under side over the entire exposure period shows the effect of protecting the doped coating from the weather. The values reported above are composite for all stations for each doping scheme over the same period of exposure. Each value indicated in Table 5 was obtained as follows: The results of tensile-strength determinations on the face fabric of each doping scheme for corresponding periods of exposure for all stations were grouped and the mean value taken as indicating the average strength result which might be expected of that particular doping scheme for the indicated length of exposure. The values for the back fabric were obtained in the same manner. It is felt that this average is a truer criterion of performance than if the results of tests on panels from only one station were reported.

CONDITION OF PANELS.

Before making detailed tests on exposed panels, notes were made on the physical appearance of each panel. It is not considered necessary to make a complete list of notes for each station for each exposure period. The relative weathering characteristics of the several doping schemes were approximately the same for each station, the only difference being one of degree of failure. The following notes were made after six months' exposure of one complete set of panels at McCook Field. The condition of each panel at the start of the test was equal to the best production finish which could be obtained for a similar doping scheme.

Clear acetate	Face: Film failure; poor. Back: No failure; good.
Clear nitrate	Face: Dope completely washed off. Back: No failure; good.
Acetate and light enamel	Face: Enamel flaked off; dope good. Back: Enamel flaked slightly; dope good.
Acetate and dark enamel	Face: Good condition. Back: Good condition.
Nitrate and light enamel	Face: Enamel flaked off; dope good. Back: Enamel flaked slightly; dope good.
Nitrate and dark enamel	Face: Good condition. Back: Good condition.
Acetate and pigmented nitrate, khaki.	Face: Good condition. Back: Good condition.
Acetate and pigmented nitrate, red.	Face: Good condition. Back: Good condition.
Acetate and pigmented nitrate, white.	Face: Pigment cracks on bending. Back: Pigment cracks on bending.
Acetate and pigmented nitrate, blue.	Face: Good condition. Back: Good condition.
Acetate and aluminized nitrate.	Face: Good condition. Back: Good condition.
Navy scheme	Face: Enamel flaked slightly; dope good. Back: Enamel flaked slightly; dope good.

DISCUSSION OF RESULTS.

The effect of weathering upon the different doping schemes can be visualized more clearly by using Figure 1 in conjunction with Table 1. The table gives the detailed tensile strength results from the panels of each station for each doping scheme. Figure 1 shows composite curves for all exposure stations for each doping scheme.

From Table 1 it is seen that the effect on the clear acetate and clear nitrate dopes without any protective covering is considerably more than the effect on the schemes having a pigmented protective covering of whatever description. It can also be seen from Table 1 that the climates of Dayton, Panama, and Virginia have the most severe effect on the performance of all dope coatings.

Figure 1, showing composite curves for each doping scheme, indicates (1) that six months' exposure is not sufficiently long to give complete life data on all of the schemes. It does, however, show marked tendencies in most cases. A second point shown by this figure is that any doping scheme using a pigmented protective covering of any description is superior to a scheme using a clear dope with or without a clear finishing coat.

The standard Air Service doping scheme, curve G, and the aluminized nitrate doping scheme, curve K, show performance and life characteristics superior to all other doping schemes. The standard covering, curve G, is heavier per unit area than the aluminized dope, but the latter is not a mat surface.

The schemes using a finishing coat of dark enamel on either clear acetate or clear nitrate dope, represented by curves D and F, are slightly superior to those using a finishing coat of light enamel (curves C and E). It is believed, however, that this difference is due entirely to relative quality of the light enamels and the dark enamels.

The strength and performance of the panel doped in accordance with the Navy scheme is about equal to those panels having a dark enamel finishing coat.

On Figures 1, 2, and 3, "Zone of complete failure," this limit was taken from a German report in Zeitschrift für Flugtechnik und Motorluftschiffart, Fr. Wendt, in which he concludes that the danger point in airplane-fabric performance is when the fabric fails under a load of 700 to 800 kilograms per meter (40 to 45 pounds per inch). This is used for convenience in showing the life limits of the various doping schemes.

In general, the outstanding features of performance of doping schemes show that a pigmented protective coating on a clear dope is more satisfactory than a clear dope alone, and that a pigmented dope is slightly superior to an enamel finishing coat.

Figure 2 shows a comparison of the weathering effect on those schemes using light or dark enamel as finishing coats. It is concluded from these curves that either nitrate or acetate clear dope and either light or dark enamel will give equally satisfactory weathering results, provided that the clear dopes and the enamels are made of high-grade materials and are of good quality.

Figure 3 shows a comparison of the weathering effect on the clear acetate panels and the clear nitrate panels. No varnish was used on these panels as a finishing coat. The life and performance of each is unsatisfactory, but the clear nitrate more so than the clear acetate.

CLEAR ACETATE AND CLEAR NITRATE DOPES WITH PIGMENTED PROTECTIVE COVERINGS.

No marked difference in performance is evidenced between the use of clear nitrate or clear acetate dope when used with a pigmented protective covering. A consideration of Tables 1, 2, 4, and 5, and figures 1 and 2 show no superiority on the part of either nitrate or acetate dope when protected from the action of sunlight.

TAUTNESS DETERMINATIONS.

The tautness determinations were made on several complete series of panels, with the idea of showing the life of the dope coating by changes in the slope of the curve obtained as described under "Procedure of tests." It was also hoped to obtain some information regarding tautness from a study of the hysteresis loops at various stages of exposure by the use of a tautness meter. These tests were not entirely satisfactory for several reasons, chief of which was that six months' exposure did not cause sufficient failure of any but the clear dope panels to show any great changes in the slopes of the curves or any great increase in the area of the hysteresis loops developed. The second reason was that, due to warping of the wooden frames used, the readings were not altogether reliable. It is believed also that tautness readings on doped wing coverings in service would be equally unreliable as a result of warping of wooden members or loosening of glued joints. Tautness determinations may have some value in the laboratory only when using some form of panel having permanent dimensions and not subject to warping or other effects causing distortion.

UNIT WEIGHTS.

Considerable variation in unit weights is shown between the various doping schemes. The clear dopes, as might be expected, are considerably lighter in weight than the other coatings having pigmented protective coverings, but their performance under weathering precludes the necessity of considering them in this discussion. Those panels having an aluminized pigmented dope or finishing coat of dark enamel are the lightest and most desirable from the designer's standpoint. The lack of uniformity in the quality of the enamels and their relatively higher price as compared with pigmented dope are the two factors which militate against the use of khaki enamel as a finishing coat. The glossy surface of the enamel is considered to be bad by some pilots, but there is not a unanimity of opinion on this point. This glossiness disappears on weathering. Another factor not previously discussed in this paper is the application of enamel under production conditions. This is more difficult than the application of a pigmented dope and the drying time is much longer.

All pigmented dope samples, except the aluminized dope, are heavier than the clear dope and dark enamels. The light enamels are as heavy as pigmented dope, due probably to the nature of the pigment used, but their weathering characteristics are unsatisfactory.

All pigmented dopes weather excellently, and while the aluminized dope can be considered ideal from a weight standpoint and a sky camouflage, it is desirable to use the other pigmented dope on account of the necessity for a khaki color for ground camouflage and red, white, and blue for insignia.

TEARING RESISTANCE.

One of the most vital properties of a doped fabric is its performance when torn. A general consideration of the theory of doping to obtain maximum tearing resistance is relevant at this point. Considering the test method known as the "strip-tear" method, where each consecutive thread is subject to shear, the maximum tearing resistance might be expected from undoped fabric. In this case the threads of the fabric can bunch up in the region of the tear, which effect is called "fabric assistance," and the maximum resistance to tearing is obtained. When the fabric is doped and the dope thoroughly brushed in, restraining each thread in its relative position, the tearing test resolves itself into what is essentially a shear of consecutive threads in the fabric with the minimum or no "fabric assistance". From this it can be seen that the diameter of the individual thread in the fabric is a function of the tearing resistance, and also that the tearing resistance varies directly as the diameter of the yarn.

The ideal condition to strive for in a doped fabric is to obtain a dope film which will break away from the fabric at the region of greatest stress when a tear starts. One way to help at arriving at this condition is not to brush in the dope film too thoroughly when doping. Any other effect obtained will be due to inherent qualities in the dope film itself.

Table 4 gives the values for tearing resistance as determined on one complete set of panels. These values are typical for each complete set, and the performace of the pigmented dope is consistently better than the enamels and clear dope in every case.

LIFE OF COVERINGS USING CLEAR DOPE AND CLEAR SPAR VARNISH.

The life of clear dope with a clear varnish finishing coat, as shown under "Results of tests," shows no great improvement in life over clear dope without the varnish, and both methods can be considered as unsatisfactory.

EFFECT OF SUNLIGHT, RAIN, ETC.

Table 5 gives detailed results showing the effect of sunlight, rain, etc. on the upper face of the panels, and the properties of the under side of the panels show the effect of protection which can be expected upon the under side of airplane wings or experimental panels.

Figure 4 shows graphically the degree of protection afforded by the various types of coverings used. All coverings using a pigmented protective coating of any description are superior to the clear coverings. The light enamels are inferior to the dark enamels and pigmented dopes, and are superior to the clear dopes. The superiority of the dark enamels and pigmented dopes over the light enamels is not believed to be due to any special properties of the pigments themselves, but is rather a difference in quality between enamels. It is plainly evident from this that some form of pigmented protective covering is much more desirable in all cases than any form of clear covering. The rate of decrease in tensile strength is also greatly in favor of pigmented dope coverings, which is of considerable importance from the standpoint of airplane maintenance.

CONDITION OF PANELS AND COVERINGS.

In general, the physical condition of the Panama samples was the worst as a result of mildew growth and water rotting. The rainfall and humidities at Panama are excessive, which will explain this condition.

The Dayton and Virginia panels show the next most severe exposure conditions, and the remaining panels show no great difference between themselves and are the least affected.

Considering the different schemes from all groups, the observer was able to classify each scheme in the following order, with reference to desirability as a service coating:

1. Pigmented dopes, including the aluminized dope.
2. Dark enamel finish.
3. Navy doping scheme.
4. Light enamel finish.
5. Clear dope and clear varnish.
6. Clear dopes.

Table 1.—*Tensile strength of doped fabrics over weathering period.*

Station.	Dope.	Original.		One month.		Three months.		Four months.		Six months.		Loss in strength over 6 months, per cent.	
		Warp.	Fill.	Warp.	Fill.	Warp.	Fill.	Warp.	Fill.	Warp.	Fill.	Warp.	Fill.
Dayton, Ohio	Clear acetate, scheme "A".	97	111	84	96	81	91	71	94	42	62	−57	−44
Panama				73	91	50	61	40	10	26	45	−73	−77
California				86	100	62	91	61	67	41	59	−58	−47
St. Michael, Alaska				98	107	78	103	80	94	79	97	−19	−13
Fort Gibbon, Alaska				101	119	99	119	91	108	76	97	−22	−13
Norfolk, Va				85	101	67	81	40	70	42	70	−57	−37
Average												−48	−39
Dayton, Ohio	Clear nitrate, scheme "B".	89	110	67	93	42	62	22	32	28	25	−69	−76
Panama				82	98	44	28	15	15	14	22	−84	−80
California				49	81	18	29	12	18	10	17	−89	−85
St. Michael, Alaska				99	115	58	87	52	66	41	51	−54	−54
Fort Gibbon, Alaska				98	117	101	112	93	113	39	64	−56	−42
Norfolk, Va				64	87			9	19			−89	−83
Average												−73	−70
Dayton, Ohio	Clear acetate and light enamel, scheme "C."	94	109	86	126	85	115	92	120	44	44	−53	−60
Panama				86	120	43	74	40	68	34	73	−64	−34
California				93	119	93	108	77	86	70	85	−25	−22
St. Michael, Alaska				97	115	97	120	87	102	80	99	−15	− 9
Fort Gibbon, Alaska				90	116	99	113	103	120	82	107	−13	− 2
Norfolk, Va				98	118	76	107	79	99	60	76	−36	−30
Average												−34	−29
Dayton, Ohio	Clear acetate and dark enamel, scheme "D."	90	110	92	117	85	118	88	112	73	84	−19	−24
Panama				88	122	75	109	22	75	71	109	−21	− 1
California				88	115	77	116	66	70	68	104	−24	− 5
St. Michael, Alaska				99	122	104	129	108	108	90	122	0	+10
Fort Gibbon, Alaska				101	119	102	132	98	124	100	120	+11	+ 8
Norfolk, Va				96	118	74	107	82	101	70	99	−22	−10
Average												−13	− 6
Dayton, Ohio	Clear nitrate and light enamel, scheme "E."	89	110	92	104	90	105	94	117	58	75	−35	−32
Panama				92	114	84	104	59	92	65	108	−27	− 2
California				75	125	67	111	51	63	72	102	−19	− 7
St. Michael, Alaska				97	123	93	113	96	127	93	122	+ 4	+10
Fort Gibbon, Alaska				89	115	73	74	61	122	94	122	+ 6	+10
Norfolk, Va				92	122	70	102	66	83	89	90	0	−18
Average												−12	− 7
Dayton, Ohio	Clear nitrate and dark enamel, scheme "F."	97	113	92	114	84	111	82	104	65	66	−33	−42
Panama				95	135	82	110	72	89	74	89	−24	−21
California				93	129	91	115	48	62	66	83	−32	−27
St. Michael, Alaska				102	135	105	124	99	114	89	109	− 8	− 3
Fort Gibbon, Alaska				102	115	102	116	97	121	95	115	− 2	+ 2
Norfolk, Va				92	114	84	105	76	98	78	104	−20	− 8
Average												−20	−17
Dayton, Ohio	Clear acetate and pigmented nitrate, khaki, scheme "G."	101	115	105	147	88	131	99	127	77	83	−24	−28
Panama				92	121	89	110	88	70	88	132	−13	+15
California				93	143	88	131	71	86	87	134	−14	+16
St. Michael, Alaska				113	131	117	120	107	136	99	126	− 2	+ 1
Fort Gibbon, Alaska				109	128	111	135	122	148	98	133	− 3	+14
Norfolk, Va				104	125	99	117			No samples.			
Average												−11	+ 4
Dayton, Ohio	Clear acetate and aluminized nitrate, scheme "K."	97	121	111	119	91	112	101	107	87	63	−10	−48
Panama				93	126	88	99	88	108	45	88	−54	−27
California				97	129	98	117	60	74	96	107	− 1	−12
St. Michael, Alaska				104	115	100	122	90	117	96	117	− 1	− 3
Fort Gibbon, Alaska				90	126	95	115	98	119	108	116	+11	− 4
Norfolk, Va				92	121	90	109	93	113	76	110	−22	− 9
Average												−13	−17
Dayton, Ohio	Navy scheme "L."	94	110	95	118	93	122	96	114	62	79	−34	−23
Panama				No samples forwarded.									
California				90	116	75	113	70	84	74	104	−21	− 5
St. Michael, Alaska				No samples forwarded.									
Fort Gibbon, Alaska				No samples forwarded.									
Norfolk, Va				82	114	90	119	79	107	82	112	−13	+ 1
Average												−23	− 9

TABLE 2.—*Slopes of tautness curves over exposure period.*

Covering.	Original.	One month.	Three months.	Four months.	Six months.
Clear acetate	1.26	1.15	1.05	1.07	.93
Clear nitrate	1.59	1.12	Complete dope failure.		
Clear acetate and light enamel	1.46	1.51	1.56	1.56	1.57
Clear acetate and dark enamel	1.19	1.26	1.21	1.36	1.37
Clear nitrate and light enamel	1.45	1.49	1.81	1.80	1.41
Clear nitrate and dark enamel	1.59	1.23	1.29	1.22	1.43
Clear acetate and pigmented nitrate, khaki	1.79	1.77	2.08	1.84	1.75
Clear acetate and pigmented nitrate, red	1.78	1.67	1.72	1.53	1.86
Clear acetate and pigmented nitrate, white	1.80	1.89	2.00	1.84	1.86
Clear acetate and pigmented nitrate, blue	1.66	1.46	1.64	1.63	1.56
Clear acetate and aluminized nitrate	1.39	1.49	1.57	1.55	1.47
Navy scheme	1.41	1.56	1.78	1.80	1.45

TABLE 3.—*Unit weights of wing coverings.*

Covering.	Original weight, ounces per square yard.	Weight after 6 months' exposure, ounces per square yard.
Clear acetate	6.4	5.7
Clear nitrate	5.6	4.2
Clear acetate and light enamel	9.3	6.1
Clear acetate and dark enamel	6.7	6.8
Clear nitrate and light enamel	9.0	7.1
Clear nitrate and dark enamel	6.7	6.5
Clear acetate and pigmented nitrate, khaki	8.4	8.4
Clear acetate and pigmented nitrate, red	8.3	7.3
Clear acetate and pigmented nitrate, white	9.2	9.0
Clear acetate and pigmented nitrate, blue	8.6	8.4
Clear acetate and aluminized nitrate	6.6	7.0
Navy scheme	9.2	9.0

TABLE 4.—*Tearing resistance.*

Covering.	Period of exposure.			
	One month.	Three months.	Four months.	Six months.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Clear acetate	3.1	3.5	3.0	3.0
Clear nitrate	3.0	2.25	.5	.5
Clear acetate and light enamel	4.5	4.0	4.8	3.5
Clear acetate and dark enamel	4.5	4.5	5.0	3.5
Clear nitrate and light enamel	3.75	3.75	4.0	2.3
Clear nitrate and dark enamel	3.5	4.25	4.0	3.0
Clear acetate and pigmented nitrate, khaki	7.0	5.0	6.0	3.0
Clear acetate and pigmented nitrate, red	3.5	6.0	6.0	3.3
Clear acetate and pigmented nitrate, white	6.0	4.5	6.0	3.3
Clear acetate and pigmented nitrate, blue	4.5	4.5	7.0	3.3
Clear acetate and aluminized nitrate	4.5	5.0	5.0	4.0
Navy scheme	3.5	3.75	5.0	3.0

TABLE 5.—*Effect of sunlight, rain, etc., on doped coverings.*

Covering.		Tensile strength, pounds per inch—Exposure period.							
		One month.		Three months.		Four months.		Six months.	
		Warp.	Fill.	Warp.	Fill.	Warp.	Fill.	Warp.	Fill.
Clear acetate	Face..	88	102	73	91	64	74	51	72
	Back..	96	113	90	112	78	111	77	100
Clear nitrate	Face..	77	65	53	63	34	45	26	38
	Back..	99	121	92	109	86	98	71	81
Clear acetate and light enamel	Face..	92	119	82	106	80	99	62	81
	Back..	96	116	86	121	86	108	83	107
Clear acetate and dark enamel	Face..	94	119	86	118	77	98	79	106
	Back..	94	120	93	118	83	101	90	116
Clear nitrate and light enamel	Face..	90	117	80	102	71	101	75	103
	Back..	91	116	88	116	81	105	83	102
Clear nitrate and dark enamel	Face..	96	124	91	114	97	98	78	94
	Back..	96	122	101	119	97	114	92	114
Clear acetate and pigmented nitrate, khaki	Face..	103	133	99	124	97	113	90	122
	Back..	108	139	99	124	94	119	97	129
Clear acetate and pigmented nitrate, red	Face..	82	130	97	123	88	108	87	112
	Back..	104	130	99	127	90	121	97	121
Clear acetate and pigmented nitrate, white	Face..	98	125	94	119	84	102	79	103
	Back..	104	133	97	122	84	105	85	108
Clear acetate and pigmented nitrate, blue	Face..	93	122	89	122	80	106	83	105
	Back..	100	118	99	121	87	113	95	118
Clear acetate and aluminized nitrate	Face..	98	123	94	113	88	106	85	100
	Back..	96	122	100	121	97	114	96	110
Navy scheme	Face..	89	115	86	118	82	102	73	98
	Back..	96	119	93	119	84	117	80	105

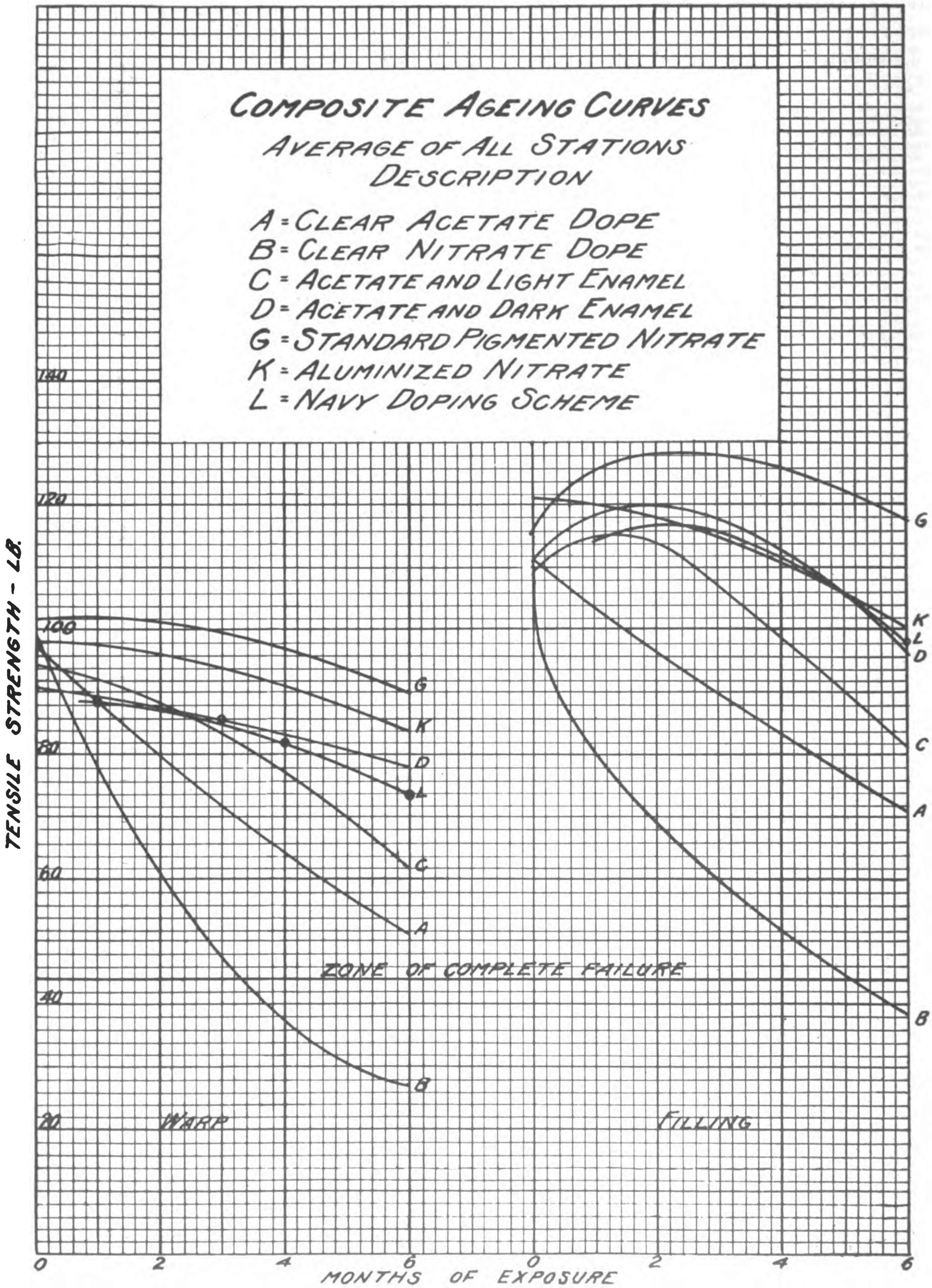
COMPOSITE AGEING CURVES
AVERAGE OF ALL STATIONS
DESCRIPTION
A = CLEAR ACETATE DOPE
B = CLEAR NITRATE DOPE
C = ACETATE AND LIGHT ENAMEL
D = ACETATE AND DARK ENAMEL
G = STANDARD PIGMENTED NITRATE
K = ALUMINIZED NITRATE
L = NAVY DOPING SCHEME
TENSILE STRENGTH - LB.
140
120
100
80
60
40
20
G
K
D
L
C
A
B
G
K
L
D
C
A
B
ZONE OF COMPLETE FAILURE
WARP
FILLING
0
2
4
6
0
2
4
6
MONTHS OF EXPOSURE

FIG. 1.

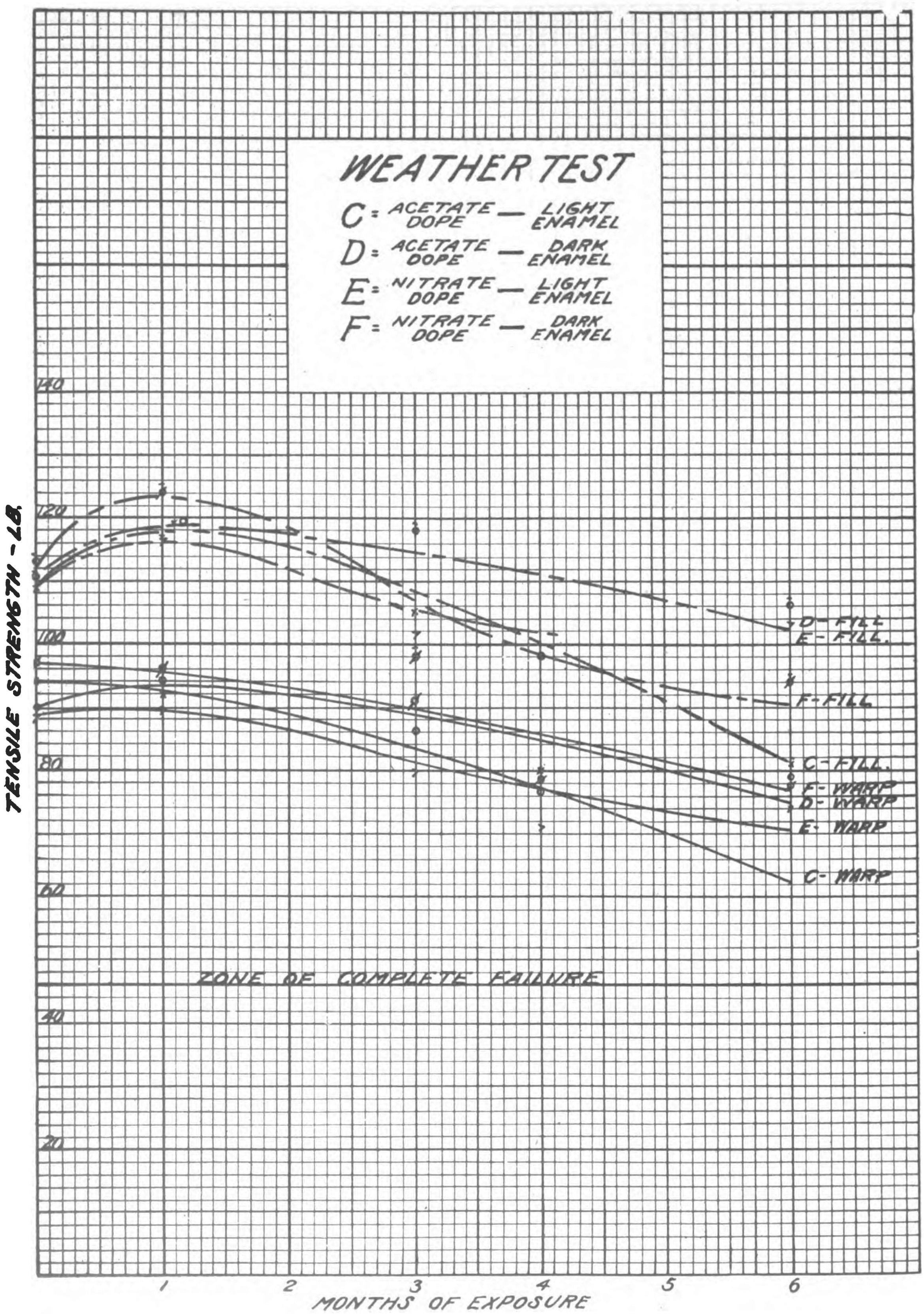
WEATHER TEST
C = ACETATE DOPE — LIGHT ENAMEL
D = ACETATE DOPE — DARK ENAMEL
E = NITRATE DOPE — LIGHT ENAMEL
F = NITRATE DOPE — DARK ENAMEL
TENSILE STRENGTH - LB.
140
120
100
80
60
40
20
D-FILL
E-FILL
F-FILL
C-FILL
F-WARP
D-WARP
E-WARP
C-WARP
ZONE OF COMPLETE FAILURE
1
2
3
4
5
6
MONTHS OF EXPOSURE

FIG. 2.

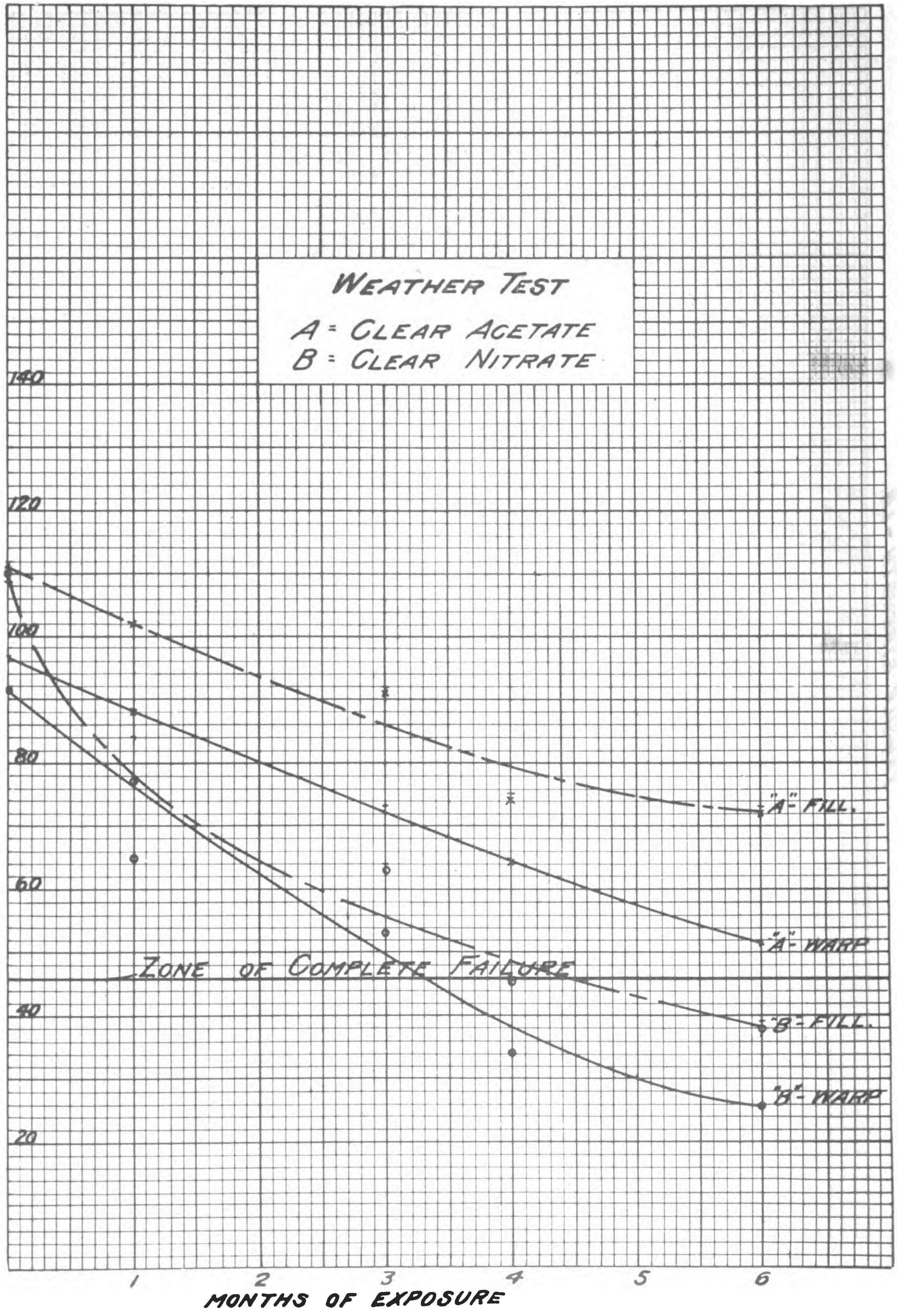
WEATHER TEST
A = CLEAR ACETATE
B = CLEAR NITRATE
140
120
100
80
60
40
20
"A" FILL.
"A" WARP
ZONE OF COMPLETE FAILURE
"B" FILL.
"B" WARP
1
2
3
4
5
6
MONTHS OF EXPOSURE

Fig. 3.

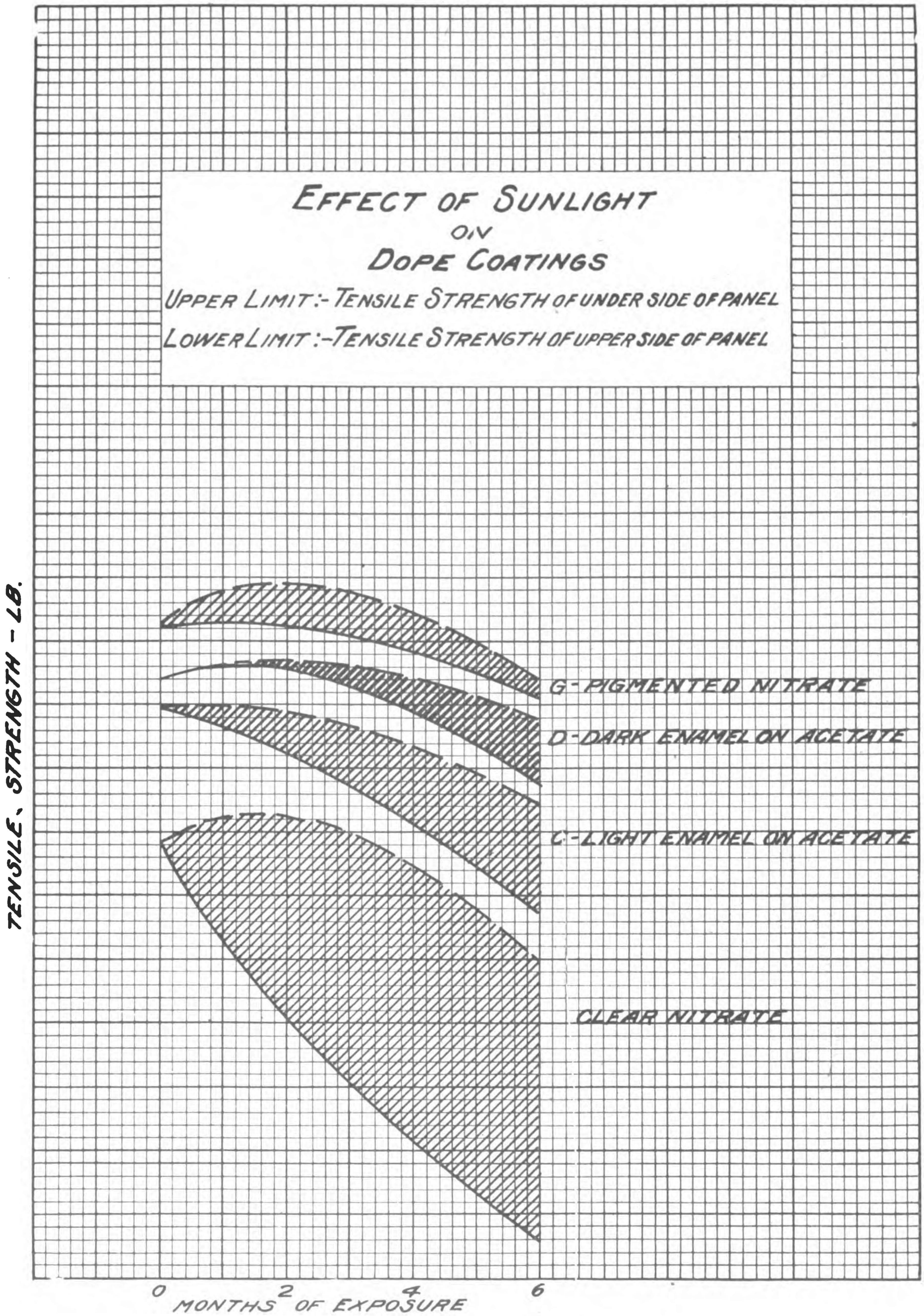
EFFECT OF SUNLIGHT
ON
DOPE COATINGS
UPPER LIMIT:- TENSILE STRENGTH OF UNDER SIDE OF PANEL
LOWER LIMIT:- TENSILE STRENGTH OF UPPER SIDE OF PANEL
TENSILE, STRENGTH - LB.
G- PIGMENTED NITRATE
D- DARK ENAMEL ON ACETATE
C- LIGHT ENAMEL ON ACETATE
CLEAR NITRATE
0
2
4
6
MONTHS OF EXPOSURE

FIG. 4.